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DYNAMICS OF SUSPENDED SEDIMENT PLUMES IN LAKE ONTARIO

Edward J. Pluhowski
U.S. Geological Survey
National Center, Mail Stop 432
12201 Sunrise Valley Drive
Reston, Virginia 22092

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(E74-10278) DYNAMICS OF SUSPENDED
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TECHNICAL REPORT STANDARD TITLE PAGE

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Figure 2A. Technical Report Standard Title Page. This page provides the data elements required by DoD Form DD-1473, HEW Form OE-6000 (ERIC), and similar forms.

Abstract

Two unusual turbidity features were detected in imagery obtained over Lake Ontario on September 19, 1973. The location of a submerged sewer outfall was detected in frame 1423-15224-5 about 2 kilometers offshore opposite a treatment plant serving Rochester, New York. The other feature was a thermal heat plume made visible by an erosive eastward moving longshore current. The thermal plume, which extended about 3 kilometers into the lake, results from the discharge of cooling water from a nuclear power plant located 20 miles east of Rochester, New York.

Under an offshore wind field, the outer edge of the Niagara River plume extended 30 kilometers into Lake Ontario on September 3, 1973. By way of contrast, a strong west-northwest wind on April 29, 1973, confined the plume to about 3 kilometers of the lake's south shore. The size of the Genesee River plume is largely dependent on discharge. During the spring high flow season, the plume extended over 22 square kilometers of the lake's surface on May 16, 1973. As runoff dwindled with the approach of summer, the plume contracted to less than 1 square kilometer in area by mid-July.

Type II Progress Report
ERTS-1

a. DYNAMICS OF SUSPENDED SEDIMENT IN LAKE ONTARIO

ERTS-1 Proposal No.: 342-4D

b. GSFC ID No.: IN 058

c. Statement and explanation of any problems that are impeding the progress of the investigation:

None.

d. Discussion of the accomplishments during the reporting period and those planned for the next reporting period:

Excellent color photography and slides were obtained at the Stanford Research Institute, Menlo Park, California during a visit to the institute on October 15-18. These photographs were obtained from a video display unit on SRI's Electronic Satellite Image Analysis Console (ESIAC). By using the console's graphing capability, scaled reproductions were made of each identifiable large-scale plume centering the south shore of Lake Ontario.

The most promising turbidity features for time-lapse sequencing are the Welland Canal and Niagara River plumes. It is hoped that several additional frames depicting these features will be forthcoming this winter. Owing to the normally cloudy sky conditions over the lake in winter, to date only one useable frame of the Niagara River outlet is available. A time-lapse sequence will be made during a return visit to SRI this spring.

Ground-truth measurements of wind speed, lake turbidity, temperature, and suspended sediment concentrations were made along the south shore of Lake Ontario. These observations were obtained during the following periods:

July 10-12
August 2, 3
September 19-21
November 13-15

Field trips will be made during the high runoff period beginning early April 1974.

e. Discussion of significant scientific results and their relationship to practical applications or operational problems including estimates of cost benefits of any significant results:

For the first time, a submerged sewer outfall from a treatment plant serving the Rochester, New York metropolitan area was detected in ERTS imagery. Previously this turbidity feature was observed on several occasions in 60,000-ft. photography provided by NASA aircraft from July 1970 to June 1972. Effluent from the outfall is discharged about 2 kilometers offshore and 3 kilometers east of the entrance to Rochester Harbor. The surface expression of the submerged outfall appears as a compact circular bright spot in bands 4 and 5 of frame 1423-15224.

Another very interesting turbidity feature on frame 1423-15224 obtained on September 19, 1973, is visible at the Robert E. Ginna Nuclear-Power Plant located about 20 miles east of Rochester, New York. The plant discharges about 900 cfs of condenser cooling water at the surface into Lake Ontario. Under full power operation, the discharging "cooling" water is as much as 10°C warmer than ambient lake temperature. Accordingly, a thermal plume is formed which tends to remain at or near the surface of the lake. Since the lake is the source of the cooling water, turbidity differences between the discharge canal water and the receiving lake water are normally very small. Accordingly, the thermal plume is rarely visible in ERTS imagery.

On September 19, 1973, moderate southwest winds (5 to 10 knots) generated a strong west-to-east longshore current which effectively eroded the exposed headlands between Rochester and the power plant. This bench erosion is shown in images 1423-15224 — 4-5 as a very bright narrow band along the shoreline immediately to the west of the plant. As the highly turbid eastward moving littoral drift reached the discharge canal jet, it was swept northward toward the center of the lake. Turbidity added to the power plant's thermal jet after mixing with the highly colored littoral drift was enough to make the jet visible in the ERTS imagery. The power plant's cooling-water effluent appears triangular in shape, with its vertex located about 3 kilometers offshore and its 2-kilometer long base oriented along the shoreline.

Many factors affect the size and shape of large turbidity features such as the Niagara River or Genesee River plumes. The most important of these in large quiescent water bodies such as Lake Ontario are wind speed and direction, volume of runoff, and differences between the levels of turbidity of the discharging water-course and that of the receiving water body. The importance of wind speed and direction is illustrated by ERTS imagery received from western Lake Ontario on April 29, 1973, and September 3, 1973. Discharge from the Niagara River is very uniform owing to the extensive storage provided by the Lakes Erie, Huron, Michigan, and Superior. Too, turbidity levels are usually low (normally 1 to 2 JTU) seldom exceeding 5 JTU at the mouth of the river. Since runoff and turbidity levels are fairly stable with time, wind speed and direction become especially important in controlling the shape of the Niagara River plume.

By way of illustration, on April 29, 1973, under the influence of brisk west-northwest winds, a strong eastward moving longshore current was generated. The shearing effect of this current on the northward moving Niagara River plume is portrayed in image 1280-15302. The plume extended only 3.2 kilometers offshore, however, it was identifiable for a distance of at least 13 kilometers downwind along the New York shoreline. The total surface area of the plume on April 29, 1973 was 34 square kilometers.

Gentle offshore winds on September 3, 1973, on the other hand, greatly expanded the size of the Niagara River plume. The southerly winds on that day reinforced the northward flowing Niagara River jet. The offshore winds pushed the leading edge of the Niagara plume about 30 kilometers into the lake. As shown in image 1407-15343-4, a large clear-water (dark) plume developed which covered 5141 square kilometers of lake surface.

The impact of varying streamflow rates is illustrated by the Genesee River plume. On May 16, 1973, during a period of high flow, the plume was detected at a distance of nearly 4 kilometers offshore -- its overall size was about 22 square kilometers (image 1297-15243-5). By way of contrast, on July 9, 1973, the plume extended only 1 kilometer offshore and covered an area of less than 1 square kilometer. Wind speed and direction were about the same on both occasions. Accordingly, the sharply reduced size of the Genesee River plume on July 9th (image 1351-15235-4) was due to low flows typical of most streams in summer.

Category designation 4D, 5H, 7C

f. A listing of published articles, and/or papers, preprints, in-house reports, abstracts of talks, that were released during the reporting period:

Talks outlining the scope and objectives of the research project were given on October 26, 1973, at the Goddard Space Center, Greenbelt, Maryland, and on December 14, 1973, at the U.S. Geological Survey National Center in Reston, Virginia.

g. Recommendation concerning practical changes in operations, additional investigative effort, correlation of effect and/or results as related to a maximum utilization of the ERTS system.

None.

h. A listing by date of any change in Standing Order Forms:

None.

i. ERTS Image Descriptor forms:

Will be updated in the next reporting period.

j. Listing by date of any changed Data Request forms submitted to Goddard Space Flight Center/NDPF during the reporting period:

None.